VARIATION OF HOOKS ON THE HIND WING OF THE HONEY BEE (*APIS MELLIFERA* L.).[1]

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The present paper represents partial results of a series of investigations carried on by the author since 1924 in the field of biometry of the honey bee (See Alpatov, 1–10). The material for this work has been collected partly during the author's work in the Zoölogical Museum of the Moscow University, and partly (material on American bees) during the summer of 1927 in the apicultural laboratory of the Agricultural College, Cornell University. The definite calculations and the preparation of the manuscript have been completed during the winter 1927–28 in the Institute for Biological Research. The author is glad to express his deep indebtedness to Professor Koshewnikov (Moscow), Professor E. F. Phillips (Cornell University), and Professor Raymond Pearl for their interest and help. The author also appreciated very much the help given by beekeepers of Russia and U. S.A. in collecting bees from different parts of both countries. Profeessor E. F. Phillips has also been so kind as to show the author the manuscript of his unpublished paper.

In spite of the fact that the beekeeper's literature contains a tremendous number of observations on differences in bee races, a scientific basis of racial studies in bees is practically absent, especially in comparison with racial and genetical studies on other domestic animals. The cause of this lies chiefly in certain peculiarities which characterize the honey bee. Firstly, the bees being fecundated in air do not allow us to control the mating and therefore to conduct exact genetical experiments. Secondly, it is more difficult to study the characteristics of such small animals as the honey bee than those of domestic mammals and birds. Only quite recent progress in artificial insemination of the queen

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(Watson, '20) gives us the hope of being able to overcome the first of these obstacles.

The present author believes that a careful investigation of variation should be made before any attempts to study the heredity of the honey bee. In this direction the present paper brings evidence of the importance of a certain characteristic, namely, the number of the hooks, characterizing different biological groups in the limits of the species *Apis mellifera* L. Thanks to the modern investigations mostly of Russian scientists (Koschewnikov, Chochlov, Michailov, Alpatov, Alpatov and Tjunin) two very important facts in the field of variation of the honey bee have been discovered.

The first of them is the geographical regularity in the variation. The changes in tongue length of the worker bee is the most striking fact in the geographical variation of the honey bee. We are able to say that for countries with native bee population each locality is characterized by a definite tongue-length of bees inhabiting the given locality. Moreover, the change from one locality to another is regular and gradual. A general rule can be established; the more to the south, the longer the tongue length. Other body characteristics also show some regularities in geographical variation (Alpatov, 8). The author of the present paper believes that it is perfectly justifiable to compare the different "races" of the honey bee with geographical subspecies of wild animals.

Family variation is the second important fact which every investigator in the field of variability of social insects has to bear in mind. It was shown by several investigators, Thomson, Bell and Pearson (23, 24), Warren (25), Arnoldi (12), Z. G. Palenitschko (20), Alpatov and Tjunin (1) and Alpatov (3, 4, 6, 9, 10), that the variation of single families is smaller than the variation of the whole population. Therefore, in establishing racial characteristics we have to collect our material from as many families as possible.

Turning our attention to the literature devoted to the special question of hook variation we find only a small number of papers dealing with that particular subject. Professor Koschewnikov (19) was the first who introduced the number of hooks in the taxonomy of the honey bee. E. B. Casteel and E. F. Phillips (14) without using biometrical methods, tried to solve the problem of comparative variability of drones and worker bees. Kellog's (17) data have also a very restricted value from the point of view of modern biometry. Wright, Lee and Pearson (27) then attempted, by recalculating Casteel's and Phillips' data, to draw some more definite conclusions. The most extensive work has been done by Bachmetjew (13). The conclusions of this author found just criticism in Koschewnokov's (18) and Ray-

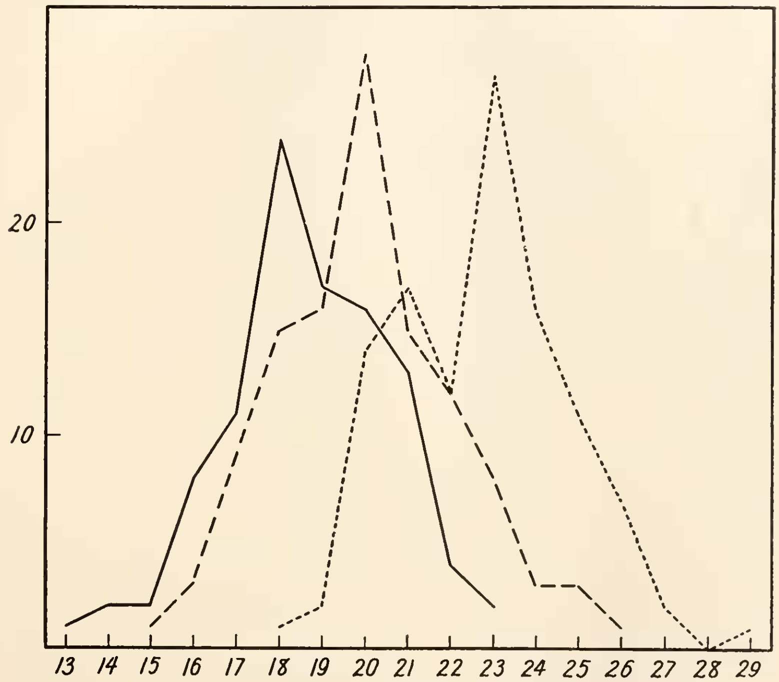

FIG. 1. Hook variation of 3 colonies of the Bulgarian drones.

mond Pearl's (21) papers and need not be mentioned further. Fortunately, Bachmetjew published in his paper all his numerous countings (about 2,500 bees were examined). His data have been worked out biometrically by the author of the present paper, and published in Russian (4). Professor Phillips did the same in the paper which is now in press. In this paper Professor Phillips turns his attention mostly to the individual variation in

TABLE I.

CONSTANTS OF VARIATION CALCULATED FOR DRONES OF 10 COLONIES OF BULGARIAN BEES TAKEN FROM DIFFERENT APIARIES.

(Data from Bachmetjew.)

	Number of the Colony.									
	1	2	3	4	5	6	7	8	9	10
M	21.56 ± .11	21.59 ± .14	22.18 ± .13	22.75 ± .13	21.16 ± .16	22.69 ± .14	22.13 ± .13	21.53 ± .13	18.68 ± .13	20.05 ± .14
σ	1.645	1.831	1.622	2.001	2.755	2.053	1.665	1.802	1.959	2.151
C%	7.63 ± .37	8.48 ± .44	7.31 ± .41	8.80 ± .40	13.02 ± .56	9.05 ± .44	7.52 ± .36	8.37 ± .41	10.49 ± .51	10.73 ± .48
Number of cases	99	83	71	110	127	100	100	93	100	114

the honey bee, and on that account his conclusions do not parallel those of the present paper.

The number of bees examined by the author of the present paper exceed three thousand—a number which has never been reached by previous investigators.

Table I. shows us the variation of Bulgarian drones belonging to different colonies. It is evident that the difference between the averages are in many cases more than five times larger than their probable errors. Fig. 1 represents 3 variation curves of the 4th, 9th and 10th colonies, proving the conclusion just made. Table II. shows the same for worker bees. It can be seen that in

TABLE II.

CONSTANTS FOR WORKERS OF 5 COLONIES OF BULGARIAN BEES (DATA FROM BACHMETJEW).

	Number of the Colony.				
	1	2	3	4	5
M	21.60 ± .10	21.01 ± .09	21.76 ± .10	21.91 ± .12	21.11 ± .10
σ	1.487	1.367	1.566	1.867	1.467
C%	6.88 ± .33	6.51 ± .31	7.20 ± .33	8.52 ± .41	6.95 ± .33
Number of cases	99	99	110	100	98

the last case the differences are not so pronounced as in the case of the drones. Fig. 2 compared with Fig. 1 gives the same impression. If we consider the coefficients of variation we find that for the drones they vary in the limits 7.52–13.02 per cent.; for the worker bees 6.88–8.52 per cent. It is obvious that the average variation of worker bees of the colony is smaller than the variation of the drones.

Are we justified in concluding that the drones are more variable than the worker bees? There is a certain weak point in such conclusions. We are not convinced that the method of collecting the material was safe enough to provide us with bees really representing the progeny of single queens—*i.e.*, members of one family. The proper way to get such a material would be to put a sealed brood in an incubator and collect the emerging bees. In collecting bees directly from the hive there is a danger of picking up bees belonging to the population of a neighbour hive. It is known that the bees and especially the drones sometimes penetrate into neighboring hives. The only way to avoid this diffi-

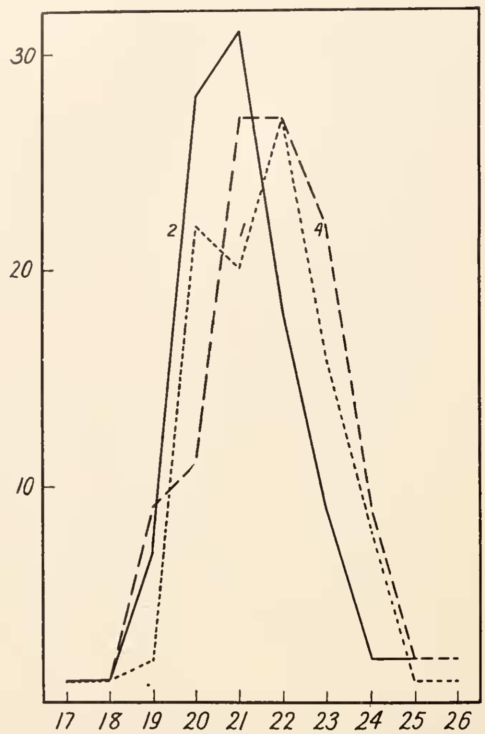

Fig. 2. Hook variation of 3 colonies of the Bulgarian worker bees.

culty is to calculate the coefficient of variation for the whole mass of bees. The results of such processes are shown in Table III. It can be seen that the variation of the worker bees belonging to

Table III.

Bulgarian Bees in Different Groupings.

All Drones 1–10 Colonies.	Workers from 5 Colonies.	Queens from 10 localities in Bulgaria.	Drones from 1–5 Colonies.	Drones from 5–10 Colonies.
21.39 ± .05	21.49 ± .05	18.46 ± .11	21.82 ± .07	20.98 ± .07
2.352	1.586	1.892	2.157	2.438
11.00 ± .17	7.38 ± .16	10.25 ± .42	9.89 ± .42	11.62 ± .25
997	507	139	490	507

the 5 colonies is lower than the variation of the two groups of drones each representing members of 5 colonies. The coefficients of variation calculated from our original material on worker bees are also in general lower than 8 per cent. Even for 1000 worker bees from Middle Russia taken from 106 colonies the coefficient of variation is only 8.539 ± .129, as can be seen from Table X. We believe that the present material permits us the definite conclusion of a larger variability of drones in respect to the number of hooks.

Table III. contains also data on variation of hooks in queens. Firstly, it is evident that the average number of hooks is far lower than in the drones and workers, which have practically the same averages. This conclusion is given here in statistical form for the first time, although G. A. Koschevnikov has already given a few analogous data. In respect of the coefficient of variation the queens are nearer to the drones than to the workers. A very incomplete material collected in Table IV. shows that Middle Russian, German and American black and yellow queens have also a much lower average number of hooks than the worker bees of the corresponding races.

Table IV.

Number of Hooks of Drones and Queens from Different Localities.

	Drones.			Queens.		
	Moscow.	Kaluga (M. Russia).	N. Wodolaga (S. Russia).	Black-Ontario.	Italians.	Moscow and Darmstadt.
M	20.72	20.22 ± .20	20.83 ± .26	16.25	18.00	18.67 ± .22
C%	—	9.76 ± .69	12.00 ± .87	—	—	9.06 ± .83
No. of cases	25	45	48	8	10	27

It is interesting to note that among the bees the relations of castes in respect of variation differ from those found in other social insects. It was shown (Palenitschenko, 20) that among wasps, termites and ants, the workers are more variable than the sexual forms—males and females. The worker caste among bees is therefore an exceptionally constant and standardized group of individuals.

Already in an earlier paper (4) some evidence has been brought together to show that the bees of southern localities have a greater average number of hooks than the northern ones. In order to check that statement on a more solid basis, a special material has been collected from different parts of European Russia and the Caucasus. The map in Fig. 3 shows the localities which supplied a

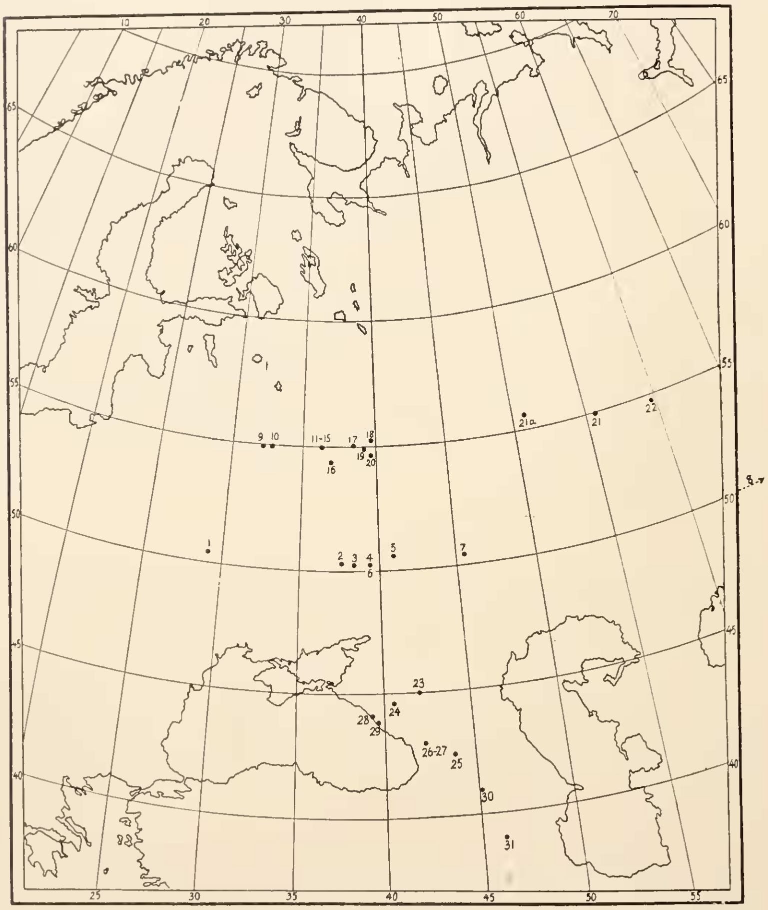

Fig. 3. Map of European Russia and Caucasus. The figures correspond to localities where the material has been collected.

corresponding material. The plain of European Russia is populated by the black variety of *Apis mellifera* L—*A. mellifera mellifera* L. An introduction of foreign blood, mostly of Italian queens, was according to certain statistical studies a comparatively rare phenomenon and could probably not produce any significant influence on the whole mass of the bee population of Russia (the number of hives in Russia according to certain estimations runs over 5,000,000). Tables V. and VI show the fre-

Table V.

Frequency Distributions and Constants of the Number of Hooks of Bees from Middle Russia.

No. of Hooks.	Localities.													
	9	10	11	12	13	14	15	16	17–18	20	19	20a	21	22
29													1	
28													—	
27	1									1			—	
26	2				1					0		1	1	
25	1		1	1	0			1	2	3		2	2	
24	6		1	3	1	2	1	1	3	0		10	4	3
23	3	4	4	9	6	2	5	4	13	7	4	10	11	9
22	20	14	12	8	13	8	11	9	8	13	4	17	21	10
21	21	19	14	6	16	10	18	16	25	10	10	18	26	8
20	24	22	13	13	13	12	13	12	22	12	11	17	22	9
19	13	25	8	8	11	18	4	10	18	3	5	13	9	10
18	8	14	2	5	1	4	7	5	4	1	4	9	3	3
17	1	1	2	1		4	1	2	2		2	2		
16		1	2	1		1	1		3					
No. of cases	100	100	59	55	62	61	61	60	100	49	40	99	100	52
No. of colonies	7	10	6	6	6	6	6	6	18	6	4	10	9	6
M	20.86 ± .13	19.99 ± .10	20.56 ± .16	20.75 ± .18	20.92 ± .12	19.97 ± .15	20.56 ± .14	20.48 ± .14	20.58 ± .12	21.48 ± .16	20.28 ± .00	21.04 ± .15	21.27 ± .12	20.98 ± .16
C%	8.97 ± .43	7.27 ± .35	8.64 ± .54	9.45 ± .61	6.77 ± .41	8.51 ± .52	7.77 ± .47	8.04 ± .50	8.94 ± .43	7.97 ± .54	7.64 ± .58	9.11 ± .44	8.14 ± .39	8.08 ± .53

quency distribution for different localities, number of colonies and corresponding biometrical characteristics. Table X. gives summarized frequencies for the bees distributed in Middle Russia at the level of 55° of N. latitude and in South Russia, 50° N. latitude. The difference between the averages is 8.85 times larger than the probable error. We may conclude, therefore, with a high degree of certainty, that there is an increase in the average

TABLE VI.

FREQUENCY DISTRIBUTION AND CONSTANTS OF THE NUMBER OF HOOKS OF BEES FROM SOUTH RUSSIA.

No. of Hooks.	Localities.						
	1	2–3	4	5	6	7	8
26	1		1	1	1		
25	3	1	0	2	2	3	
24	4	7	2	5	4	8	2
23	10	12	6	7	6	4	7
22	17	18	11	10	12	13	10
21	10	19	8	11	24	8	20
20	10	22	6	12	21	8	14
19	5	15	9	5	15	4	4
18	3	3	4	6	7	1	3
17	1	3	1	1		1	
No. of cases	64	100	48	60	92	50	60
No. of colonies	6	18	10	6	9	5	6
M	21.52 ± .16	20.94 ± .12	20.88 ± .18	21.13 ± .18	20.75 ± .12	21.68 ± .18	20.98 ± .12
C%	8.59 ± .51	8.29 ± .40	8.98 ± .62	9.53 ± .59	8.21 ± .41	8.63 ± .58	6.60 ± .41

number of hooks in the southern direction even between groups of bees in comparatively closely situated localities. Turning our attention to the Caucasus (Fig. 5) we must say that the situation here is more complicated than in the plain of European Russia. Zoögeographically, the Caucasus is divided into several sharply limited provinces, each of them with peculiarities in the composition and the origin of the organic life. The Caucasus bees are also not homogenous. The best characterized is the gray Caucasian mountain bee *Apis mellifera caucasica* Gorbatschev and the yellow Transcaucasian so-called Persian bee. This bee was first recognized as an independent species by Pallas; although he did describe the Caucasian bee he has never published his manuscript. The specimen with the original label is preserved in the Berlin Zoölogical Museum and was briefly described by

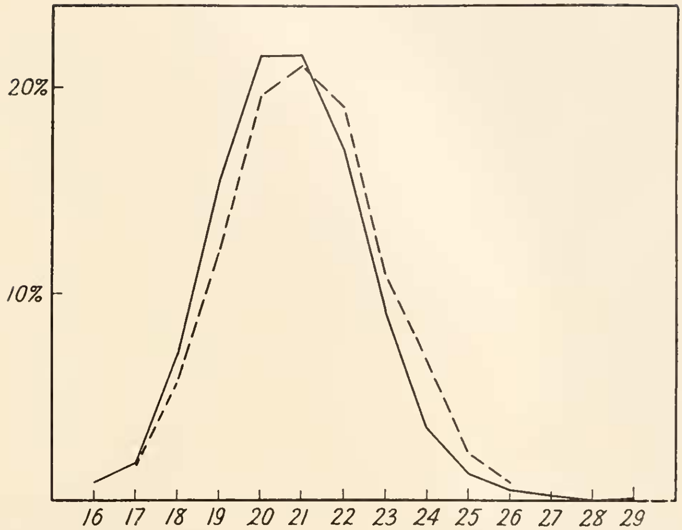

FIG. 4. The continuous curve represents the variation of hooks of bees from Middle Russia. The dotted, is based on material from South Russia. The frequencies are expressed in percents.

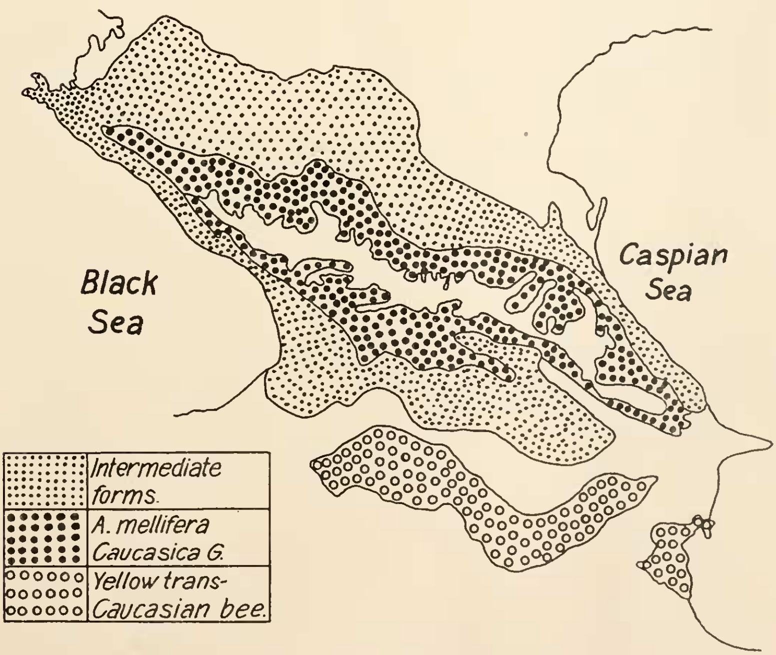

FIG. 5. Map of Caucasus showing the distribution of fifteen variations of bees (after A. Gorbatschev).

Table VII.

Frequency Distributions and Constants of the Number of Hooks of Caucasian Bees.

No. of Hooks.	N. Caucasus.			Caucasus Mountains.					Abchasia.					Transcaucasia.		
	Stavro-pol 23.	Maikop 24.	Σ.	Tiflis 25.		Svanetia 26.	Kutais 27.	Σ.	$\frac{I}{28}$.	$\frac{II}{28}$.	$\frac{III}{28}$.	29.	Σ.	Migri 30.	Delid-jan 31.	Σ.
27														1		1
26							1	1						1		1
25	1	2	3	1	3		0	4	1	2			3	0		0
24	2	1	3	0	3	2	2	7	0	1	2	4	7	2	3	5
23	10	8	18	6	2	10	2	20	9	4	9	8	30	4	7	11
22	24	19	43	13	5	10	9	37	6	9	9	10	34	8	14	22
21	40	24	64	9	6	6	9	30	9	10	19	17	55	4	8	12
20	43	30	73	12	4	4	4	24	8	8	12	13	41	8	6	14
19	24	12	36	7	1	2	5	15	9	5	5	8	27	1	1	2
18	6	3	9	2		2		4	3	2	2	5	12		1	1
17	5	1	6								2	0	2			
16	1		1									0	0			
15												0	0			
14												1	1			
No. of cases	156	100	256	50	24	36	32	142	45	41	60	66	212	29	40	69
No. of colonies	?	many	—	8	7	several	?	—	9	10	12	about 10	—	3	4	7
M	20.47 ±.11	20.79 ±.10	20.61 ±.06	20.94 ±.14	22.00 ±.24	21.61 ±.17	21.31 ±.19	21.33 ±.10	20.84 ±.17	21.10 ±.17	20.95 ±.14	20.82 ±.15	20.91 ±.08	21.79 ±.23	21.65 ±.14	21.71 ±.13
C%	7.31 ±.28	6.94 ±.33	7.14 ±.21	7.11 ±.48	7.87 ±.77	7.19 ±.57	7.49 ±.63	7.91 ±.32	8.14 ±.58	7.18 ±.58	7.42 ±.46	8.73 ±.52	7.93 ±.26	8.42 ±.75	6.16 ±.46	7.19 ±.41

TABLE VIII.

DIFFERENCES BETWEEN THE AVERAGE NUMBER OF HOOKS IN DIFFERENT GROUPS OF BEES.

		55°.	50°.	North Caucasus.	Abchasia.	Caucasus Mountains.	Trans-caucasia.	Italy.	American Italians.	American Black Bees.
		20.70 ± .04	21.08 ± .06	20.61 ± .06	20.91 ± .08	21.33 ± .10	21.71 ± .13	21.51 ± .08	21.00 ± .06	19.63 ± .09
55°.	20.70 ± .04	0								
50°.	21.08 ± .06	0.62 ± .07 R = 8.85	0							
North Caucasus.	20.61 ± .06	0.09 ± .07 R = 1.29	0.47 ± .08 R = 5.88	0						
Abchasia.	20.91 ± .08	0.21 ± .09 R = 2.3	0.17 ± .10 R = 1.70	0.30 ± .10 R = 3.00	0					
Caucasus Mountains.	21.33 ± .10	0.63 ± .11 R = 5.73	0.25 ± .12 R = 2.08	7.2 ± .12 R = 6.00	0.42 ± .13 R = 3.23	0				
Transcaucasia.	21.71 ± .13	1.7 ± .14 R = 7.22	0.63 ± .14 R = 4.5	1.10 ± .14 R = 7.86	0.80 ± .15 R = 5.33		0			
Italy.	21.51 ± .08	0.81 ± .09 R = 9.00	0.43 ± .10 R = 4.3	9.0 ± .10 R = 9.0	0.60 ± .11 R = 5.45	0.18 ± .13 R = 1.38	0.20 ± .15 R = 1.33	0		
American Italians.	21.00 ± .06	0.30 ± .07 R = 4.29	0.08 ± .08 R = 1.00	0.39 ± .08 R = 4.87	0.09 ± .10 R = 0.09	0.33 ± .12 R = 2.75	0.71 ± .14 R = 5.07	0.51 ± .09 R = 5.67	0	
American black bees.	19.63 ± .09	1.07 ± .10 R = 10.7	1.45 ± .11 R = 13.2	0.98 ± .11 R = 8.90	1.28 ± .12 R = 10.66	1.70 ± .13 R = 13.08	2.08 ± .16 R = 13.00	1.88 ± .12 R = 15.66	1.37 ± .11 R = 12.45	0

Gerstäcker (15). The author of the present article was able, thanks to the courtesy of the curator of the collection of Hymenoptera of the Berlin Zoölogical Museum, Professor Dr. H. Bischoff, to examine Pallas's specimen as well as his manuscripts. Pallas gives in his manuscript the following indication about the origin of his Caucasian yellow bee: "Ad Caucasum lecta, itemque ex Hyrcania transmissa fuit." The small size and pronounced yellow coloration of the specimens preserved in the Berlin Museum permit us to conclude that Pallas and Gerstäcker described under the name *Apis remipes,* the Transcaucasian Persian bee, but not the north Caucasian darker bees.

Some peculiarities—for instance a much longer tongue—distinguish *Apis mellifera remipes* Gerstäcker (not Pallas) from the Italian bee *Apis mellifera ligustica Sp.* It is therefore not correct to identify the *A. m. remipes* with the Italian bees (*Apis ligustica*) as it has been done by G. A. Koschewnikov. According to Gorbatschev (see the map in Fig. 5 taken from his article (16)) the prairies and hills of the northern Caucasus and the valleys of Transcaucasia are populated by a bee of intermediate type—hybrids in his interpretation. We united our material into four groups: (*a*) N. caucasus bees, (*b*) bees from four apiaries near the coast of the Black Sea—Abchasian, (*c*) gray Caucasian mountain bees (*A. mellifera caucasica* Gorb.) and (*d*) yellow Transcaucasian bees (*Apis mellifera remipes* Gerst.). Table VII. shows the frequency distributions and Table VIII. gives us material for estimating the importance of our differences. The *Apis m. caucasica* and *remipes* show a pronounced higher number of hooks than bees of South Russia. Of course such a comparatively limited number of colonies from N. Caucasus does not permit us to draw a perfectly definite conclusion. It is interesting to note that the gray Caucasian bees imported to the United States (see Table IX.) gave also a high average of the number of hooks.

Table IX. gives us some data on other European races of bees. The Italian bees from Italy are characterized by a high number of hooks. It can be seen that the progeny of Italian queens imported from Italy to N. Caucasus shows also a high number of hooks. The German black bees, according to our recalculations

Table IX.

Bees from Different Localities in Europe and U. S. A.

No. of Hooks.	Caucasians from Colorado.	Italians from Italy.	Black Bees.				Italians from Caucasus.	German Black Bees (Armbruster).	Italians in U. S. A.							
			Florida.	N. Carolina.	Ontario.	Total.			Alabama 1.	Kentucky.	Alabama 2.	Ohio 1.	Ohio 2.	New York.	Ithaca, N. Y.	Pennsylvania.
26	1						1	0								
25	—	2					1	4			1			1	1	1
24	2	13		4		4	5	9	3	3	3	2	6	2	2	—
23	10	26		3		3	9	27	5	7	8	8	10	1	4	3
22	11	32	5	9	1	15	13	37	7	11	9	14	7	10	12	14
21	19	43	5	9	6	20	10	49	16	14	14	10	12	15	18	11
20	9	19	11	11	11	33	6	55	11	3	7	8	9	10	5	10
19	4	10	16	8	17	41	4	28	3	8	3	4	4	8	5	8
18	4	4	9	7	10	26	0	14	3	4	5	4	2	2	3	4
17		1	4	2	3	9	1	5	2					1	2	1
16				1	2	3		1								
No. of cases	60	150	50	54	50	154	50	230	50	50	50	50	50	50	52	52
No. of colonies	10	10	10	10	10	30	7	7	10	10	10	10	10	10	10	10
M	21.22 ±.14	21.51 ±.08	19.38 ±.13	20.37 ±.18	19.08 ±.12	19.63 ±.09	21.74 ±.21	20.84 ±.09	20.84 ±.16	21.06 ±.16	21.20 ±.15	21.16 ±.14	21.44 ±.16	20.72 ±.15	20.96 ±.16	20.57 ±.15
C%	7.46 ±.46	7.12 ±.28	7.07 ±.48	9.42 ±.61	6.78 ±.46	8.45 ±.32	7.51 ±.51	8.57 ±.27	7.87 ±.53	7.85 ±.53	7.40 ±.50	6.70 ±.46	7.64 ±.52	7.48 ±.50	8.02 ±.53	7.74 ±.51

TABLE X.

No. of Hooks.	1		2		3		4		5		6	
	♂ from 10 Colonies Bulgaria.		☿ from 5 Colonies Bulgaria.		☿ Middle Russian Bees.		☿ South Russian Bees.		☿ Italian Bees in U. S. A.		♂ from 1 Colony (Data from Phillips).	
	Ob-served.	Calcu-lated.	Ob-served.	Calcu-lated.	Ob-served.	Calcu-lated.	Ob-served.	Calcu-lated.	Ob-served.	Calcu-lated.	Ob-served.	Calcu-lated.
29.......	2	.81			1	0.20						
28.......	4	2.69			—	0.52						
27.......	9	9.34			2	1.40					2	1.64
26.......	21	24.01	5	2.14	5	3.99	4	2.32			8	6.91
25.......	52	51.34	12	9.68	13	11.60	11	9.41	4	4.83	21	21.52
24.......	84	91.22	34	36.12	35	32.93	32	27.80	21	17.60	54	49.74
23.......	149	134.73	81	81.13	91	84.15	52	59.74	46	46.82	82	85.15
22.......	154	165.41	112	122.08	168	171.39	91	93.65	84	82.77	104	107.93
21.......	183	168.76	121	122.68	217	243.76	100	106.93	110	100.00	98	101.40
20.......	142	143.07	97	82.60	215	222.94	93	88.87	63	82.57	74	70.61
19.......	87	100.92	33	37.21	156	134.34	57	53.86	43	46.65	38	36.40
18.......	61	59.05	8	11.24	70	59.20	27	23.76	27	18.00	15	13.93
17.......	31	28.75	4	2.26	18	21.95	7	7.65	6	4.75	3	3.94
16.......	11	11.63			9	7.60					1	0.83
15.......	4	3.91										
14.......	2	1.09										
13.......	1	0.25										
N.......	997	996.98	507	507.1	1,000	995.97	474	473.99	404	403.99	500	500.00
M.......	21.392 ± .050		21.485 ± .047		20.698 ± .038		21.082 ± .055		21.003 ± .054		21.708 ± .055	
σ.......	2.32525 ± .03511		1.57795 ± .03342		1.76733 ± .02665		1.77672 ± .03893		1.62084 ± .03846		1.82631 ± .03896	

TABLE X. (*Continued.*)

No. of Hooks.	1	2	3	4	5	6
	♂ from 10 Colonies Bulgaria.	☿ from 5 Colonies Bulgaria.	☿ Middle Russian Bees.	☿ South Russian Bees.	☿ Italian Bees in U. S. A.	♂ from 1 Colony (Data from Phillips).
C %......	10.870 ± .164[1]	7.344 ± .156	8.539 ± .129	8.428 ± .185	7.717 ± .183	8.413 ± .179
β_1.......	0.001585 ± .000723	0.019907 ± .010763	0.078324 ± .026122[2]	0.031206 ± .014291	−0.021689 ± .010207	0.000795 ± .000373
Ratio $\frac{\beta_1}{\text{P.E.}}$	2.192	1.850	2.998	2.184	2.124	2.131
β_2.......	3.247403 ± .146382	3.045287 ± .165798	4.194584 ± .104515[2]	2.719259 ± .107575	2.685580 ± .108751	2.817037 ± .110263
Ratio $\frac{\beta_2}{\text{P.E.}}$	1.690	0.273	11.429	2.610	2.89	1.708
K.......	0.002423	0.486326	0.027443	−0.037931	0.023560	−0.001621
Type....	Normal curve	?	VII	Normal curve	Normal curve	Normal curve
Goodness of fit...	.7326	.3131	.2602	.8775	.1819	.9977

[1] Calculated from the abbreviated formula like for all the other C. of V. Equation of the curve of the ☿ (Middle Russia, type VII)

$$y = 248.833 \quad 1 + \left(\frac{x^2}{21.935047}\right)^{-5.01133}.$$

[2] Calculated for normal curve of errors.

of Armbruster's data, give a number which corresponds to that of the Middle Russian ones.

Summing up now our whole material on European races we may say that there is much evidence for an assumption of a high number of hooks in southern races in comparison with northern ones. The Bulgarian group of bees also supports this conclusion. It would be interesting to test this rule on other castes of bee colonies. Unfortunately our material on drones from Russia is very small (see Table IV.), although it can be seen that the Middle

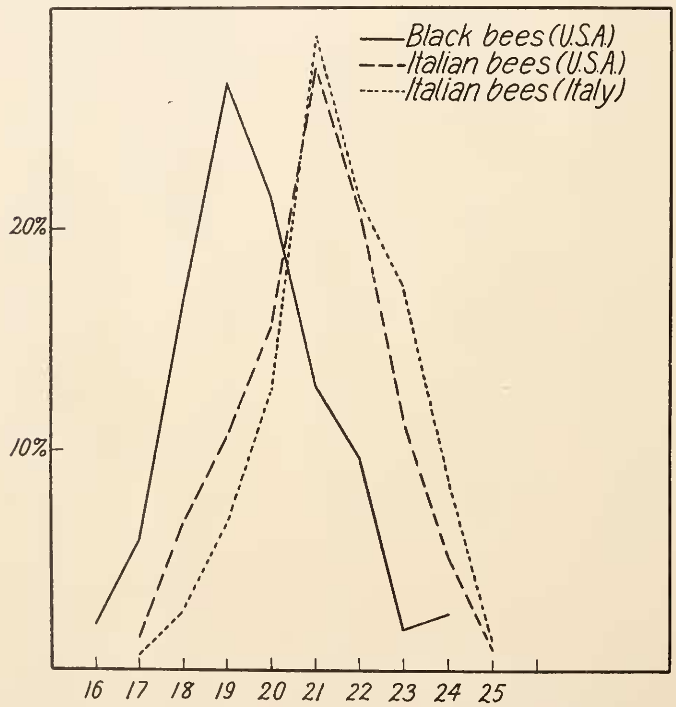

FIG. 6. Curves of variation of hooks. Continuous line—black bees in U. S. A.; dotted line—Italian bees from Italy; dash line—Italians in U. S. A.

Russian and even South Russian drones have a smaller average number of hooks than the Bulgarian ones. It would not be wise to draw any conclusions about the geographical differences in queens based on such a small number of cases. We have to add that Middle Russian and South Russian drones give the high degree of variation (C%) usual for drones.

It is well known that at the time of the discovery of the New World, America had no native bees. The first bees imported to this country came, according to historical data, from Holland and England and belonged to the common black bees *A. mellifera mellifera* L. About the middle of the last century the American beekeepers began to prefer for cultivation the yellow Italian bee, which is now the dominant race in this country. Thanks to the help of many beekeepers I have succeeded in examining, from a considerable number of apiaries, Italian bees of different degrees

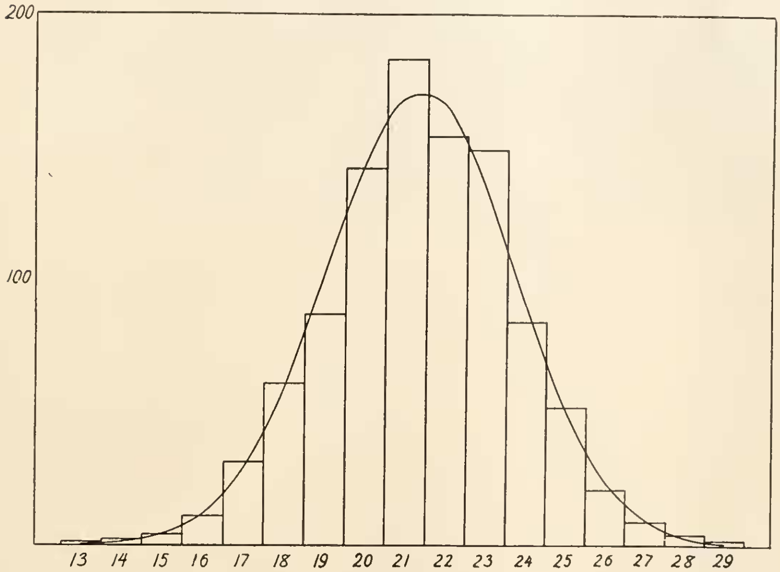

FIG. 7. Frequency polygon and fitted curve of the variation of the hooks of the Bulgarian drones.

of development of yellow color as well as pure black bees. Tables IX. and X. show us the variation of bees acclimatized to the United States. Firstly, we have to note the great difference in the number of hooks of black and yellow American bees, secondly, a little lower number of hooks of Americanized Italian bees than that of true Italians reared either in Italy or from Italian queens imported directly from that country. This is illustrated by curves on Fig. 6. The very low average number of American black bees as compared with our material discussed above give us the right to suppose a general decrease of the number of hooks in the United States as compared with Europe, both in black and yellow bees. Further investigations need to be made with special attention to the problem of influence of acclimatization upon physical characteristics in the honey bee.

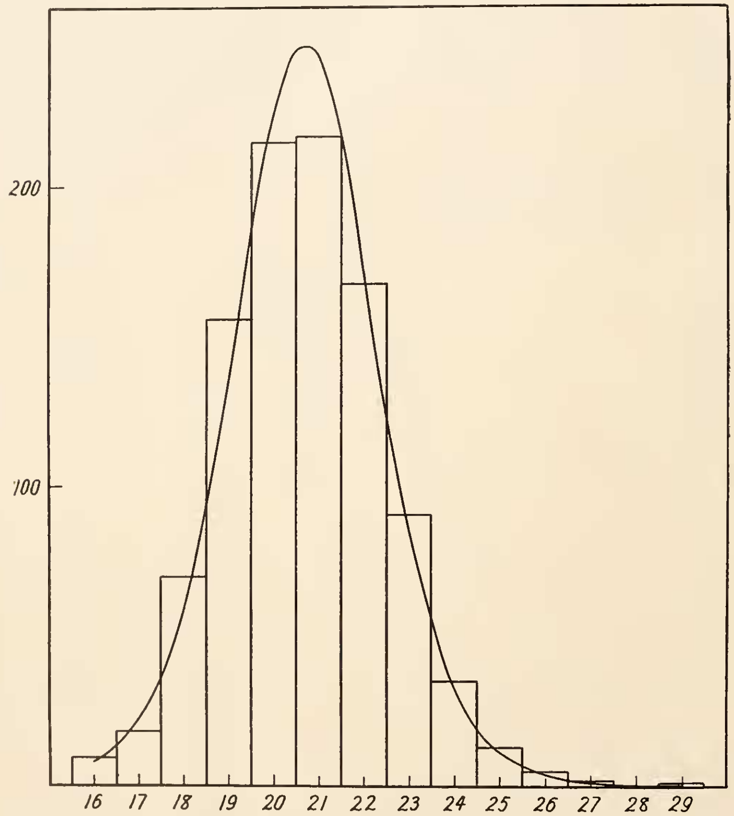

FIG. 8. Frequency polygon and fitted curve of variation of the worker bees from Middle Russia.

Our comparatively large material gave us the possibility of determining the character of the frequency distributions. The results are given in Table X. All distributions are symmetrical and only one shows a deviation from the normal distribution. A curve of type VII. was chosen to fit this distribution. The distribution for the Bulgarian worker bees being symmetrical and normal in regard to the β_2 gave a very high value of the criterion, which leads us to the curve of type IV. It was not possible to calculate the probable errors of the criterion, β_1 and β_2 being too close to those characterizing the normal curve of error. Therefore a normal curve was used for fitting. We used for calculating the ordinates of the normal curve from Pearson's "Tables for Statisticians and Biometricians." Figs. 7 and 8 show two of our curve fittings.

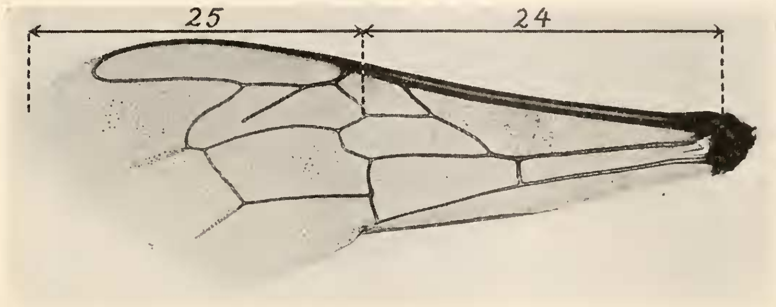

Fig. 9. Measurements on the wing. The wing shows the intercubitus vein not developed. (Microphotograph taken in the Art Department of the Institute for Biological Research, by Mr. Johansen.)

During the author's residence at Cornell University an attempt was made to study the influence of undernourishment of larvæ upon the characteristics of adult bees. The experiment consisted in putting the unsealed brood in an incubator running at 34.5° C. The brood was taken from a comb approximately one day before normal sealing. On the following day the cells situated in the neighborhood of the place from which a piece of comb had been taken the day before were already sealed by bees and also put in the incubator in order to provide us with control insects. Bees normally developed in hives were also collected from the frame of the hive which gave us material for the experiment. The pieces of comb with unsealed larvæ put in the incubator were covered with pieces of artificial comb foundation in substitution for the natural capping bees. The larvæ wove cocoons as usual and the emerging bees were collected in alcohol. The bees emerging from the unsealed brood evidently suffered from a certain underfeeding in comparison with control bees. Table XI. shows that the

TABLE XI.

CONSTANTS OF WING MEASUREMENTS OF CONTROL AND UNDERFED (IN LARVAL STAGE) BEES IN MM.

	Proximal Length of Wing (Meas. N 24).	Distal Length of Wing (Meas. N 25).	No. of Cases.
Experimental (underfed) bees.......	4.525 ± .021	4.192 ± .023	46
Control bees.....................	4.696 ± .010	4.353 ± .012	31

experimental bees have a smaller size of wings than the controls. The characteristics have been measured, as is shown in Fig. 9. Table XII. shows the average number of hooks in three groups.

TABLE XII.

INFLUENCE OF UNDERFEEDING ON THE NUMBER OF HOOKS AND THE ABNORMAL VENATION.

Character.	M ± P.E.	C%±P.E.	Percentage of Wing with Abnormal Vein.	Number of Specimens.
1. Bees taken from the hive...	20.77 ± .16	7.34 ± .56	0.00 —	39
2. Bees reared in the incubator from brood normally fed..	20.60 ± .15	7.33 ± .52	4.44 ± 1.37	45
3. Bees reared in the incubator from underfed brood.....	19.71 ± .09	7.39 ± .33	19.82 ± 2.50	116
Diff. 1–3....................	1.06 ± .18 R = 5.89	—	19.82 ± 2.50 R = 7.93	
Diff. 2–3....................	0.89 ± .17 R = 5.24	—	15.38 ± 2.85 R = 5.40	

It can be seen that the underfed bees have a smaller number of hooks than the control bees reared from the sealed brood and taken directly from the hive. The same is expressed in graphical form on curves of the Fig. 10. The experimental bees showed a quite peculiar type of abnormality in the venation of the first pair of wings. The abnormality consists in the incomplete development of the second intercubitus vein. The percentage expression of this abnormality in our three groups shows that the abnormality occurs also in bees reared in the incubator from normally sealed broods but reaches a very high grade of development in undernourished bees. The abnormalities in insect wings have been many times the subject of careful morphological studies. Our experiment opens a way for studying this problem by means of the experimental method. It is worth while to note that in geographical races the southern bees, being usually smaller than

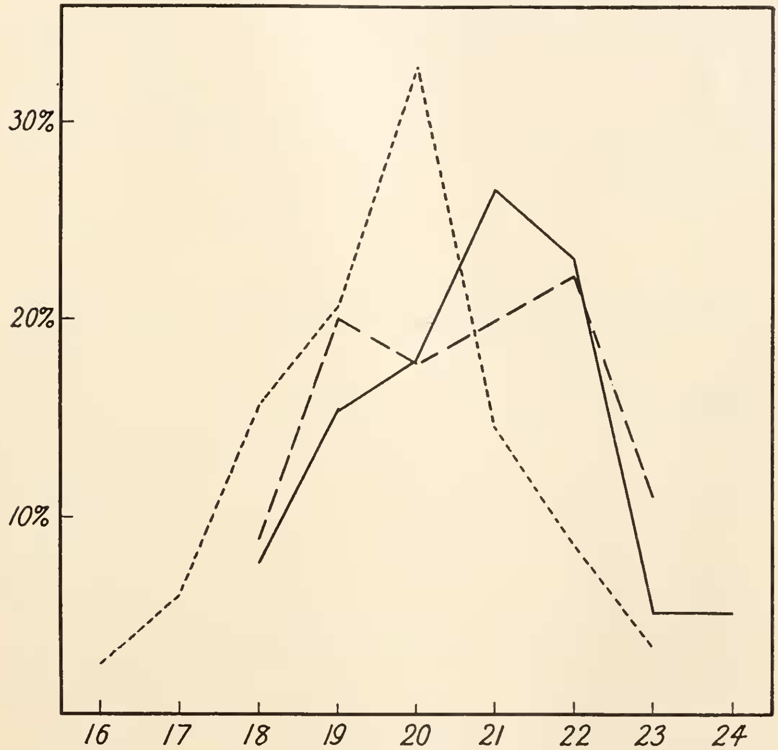

FIG. 10. Continuous line—bees from the hives which gave larvæ for the experiment with underfeeding. Dotted line—variation of hooks in the group of bees emerged from underfed larvæ. Dashed line—control bees developed from normally fed larvæ and emerged in the incubator together with underfed bees.

the northern one (Alpatov, 8), at the same time show an increase in the number of hooks. Our experimental bees gave the contrary relation. Therefore it is not possible to explain the smaller number of hooks of the northern bees by the assumption of an underfeeding of larvæ.

Summary.

The data presented in this paper show that the average number of hooks in the honey bee is a characteristic which is differently developed among single colonies, sexes, castes, and races. As a general rule the southern races have a large number of hooks in worker bees and probably in drones. The queens and drones are more variable in regard to this character than the worker bees. In this respect the relations differ from those in other social insects (ants, wasps and termites), where the asexual caste is the most variable. The experiment with underfeeding of larvæ showed a decrease of the average number of hooks and the producing of specimens with defective venation—incomplete second intercubitus vein.

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